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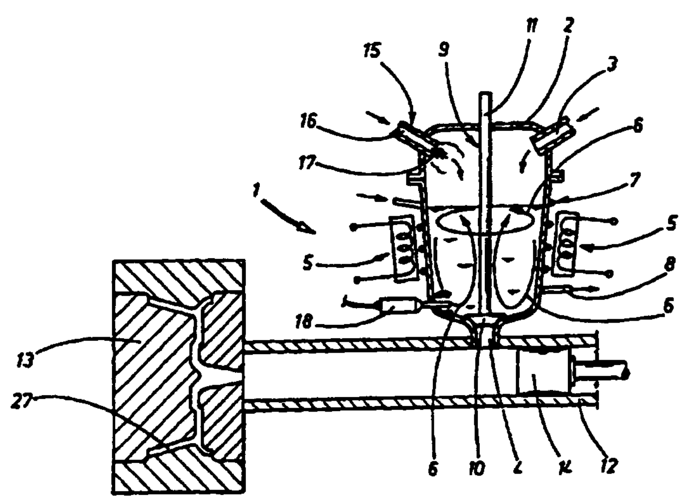
(54) Title: A METHOD AND DEVICE FOR THE THIXOTROPIC CASTING OF METAL ALLOY PRODUCTS




(57) Abstract

A method and device for the thixotropic casting of metal alloy products, especially wheel rims, envisages that a quantity of metal alloy in the liquid state be poured into a container (2), cooled and simultaneously agitated until it reaches a thixotropic state; the metal allow in the thixotropic state is then fed directly into an injection chamber (12) and injected into the forming cavity of a mould (13); magnetodynamic devices (5) agitate the metal alloy in the container (2) in two directions of rotational motion, one horizontal and one vertical; the bottom of the container (2) has an outlet (4) with a valve (9) to stop the flow of metal alloy and the injection chamber (12) is equipped with a plunger (14) that slides axially inside the chamber itself so as to inject the alloy into the mould (13).

# Description

## A method and device for the thixotropic casting of metal alloy products

### Technical Field

The present invention relates to a method for the thixotropic casting of metal alloy products.

The invention applies in particular to the manufacture of aluminium alloy wheel rims and it is to this field of application that the description below expressly refers but without thereby restricting the scope of the disclosure.

The thixo-casting process consists basically in preparing a solid block (in the form of a billet, ingot, bloom, etc.) of material (the metal alloy) with a thixotropic structure, heating the block to a ductile semi-solid state and then injecting the semi-solid block into a mould.

### Background Art

The thixo-casting process presents a number of disadvantages, however.

The first disadvantage is that the heat cycle envisages two heating operations and two cooling operations, requiring considerable quantities of energy; moreover, two different machines are necessary, one for forming the intermediate, thixotropic product (usually billets) that will be formed into the desired shape by the other machine, that is, the die casting machine. Moreover, the process requires a smelting furnace, a reheating furnace to heat the thixotropic billets to a semi-solid state and suitable means for transferring the "hot" billets from the furnace to the injection chamber of the die casting machine.

The second disadvantage of the thixo-casting process is that it has a high wastage rate of material in the thixotropic state, that is, material with a high unit cost. The billets are usually obtained by cutting a continuous bar. Moreover, considerable amounts of material are lost by dripping off the billets during reheating and during their transfer from the furnace to the casting machine.

The third disadvantage is that the surface of the billets oxidizes very easily, thus causing further loss of material and making it necessary to inhibit oxidization so as to prevent the formation of oxide inclusions during the moulding stage.

A further disadvantage of the thixo-casting process is the difficulty of obtaining parts with complex shapes and good mechanical properties. This is because the metal which fills the mould is not very fluid since it has to be injected at a relatively low temperature, very near the solidus, in order to reduce dripping, oxidation, billet deformation, etc.

Yet another disadvantage is that the billets have to be stored and transported from the place where they are produced to the place where they are formed.

In rheocasting, a mass of thixotropic metal alloy is prepared at a temperature between liquidus and solidus and the metal is then poured directly into the mould. Unlike thixo-casting, there is no need for an intermediate step to produce a solid block with a thixotropic structure.

A rheocasting machine usually includes a large chamber into which the metal alloy in the form of pellets is fed. The metal is heated to a preset temperature in this chamber. At the same time, a screw unit agitates the metal to obtain the thixotropic structure. The screw is also used to inject the

metal into the mould.

Rheocasting also has several disadvantages, however.

The first is that the machine required for rheocasting is considerably complex and expensive.

The second is that, like thixo-casting, rheocasting is unsuitable for making parts with complex shapes and good mechanical properties. When the metal fills the mould cavity, its fluidity is very low (usually, its temperature is just above the solidus) otherwise the screw cannot mix and inject it.

Disclosure of the Invention

The aim of the present invention is to provide a simple, economical method for the thixotropic casting of metal alloy products that is capable of overcoming the abovementioned drawbacks.

The present invention discloses a method for the thixotropic casting of metal alloy products characterized in that it comprises the following stages: pouring a quantity of molten metal alloy into a container; cooling and, at the same time, agitating the metal alloy until it reaches a thixotropic state; feeding the metal alloy in the thixotropic state into an injection chamber; injecting the metal alloy into a mould cavity.

The present invention also discloses a device for the thixotropic casting of metal alloy products.

The present invention provides a device for the thixotropic casting of metal alloy products characterized in that it comprises: a container for a molten metal alloy equipped with at least one inlet and one outlet for the metal alloy; means for agitating and means for cooling the metal

alloy in the said container in order to give the metal a thixotropic structure; a cutoff valve on the said outlet; an injection chamber connected to the said container through the outlet; means for transferring the metal alloy from the container to the injection chamber; a mould for metal alloy products connected to the injection chamber; means for injecting the metal alloy from the injection chamber into the mould.

An advantage of the present invention is that it permits the forming of parts with complex shapes - such as, wheel rims, for example - and good mechanical properties.

Moreover, thanks to the method disclosed by the present invention, the fluidity of the thixotropic metal alloy when it is injected into the mould cavity is relatively high. In other words, the invention permits injection of a thixotropic metal alloy having a relatively high percentage of liquid.

Another advantage is that it prevents the formation of undesirable non-globular dendrites.

Yet another advantage of the invention is that the heat cycle envisages only one heating operation and only one cooling operation. This reduces waste of thixotropic material with a high unit cost and minimizes the risk of oxidation of the metal alloy.

The invention will now be described with reference to the accompanying drawings which illustrate embodiments of the invention by way of example only and in which:

- Figure 1 is a schematic cross section of an embodiment of the device disclosed by the present invention;
- Figure 2 is a cross section of another embodiment of the device disclosed by the present invention;
- Figure 3 is a cross section of a part of the device showing

a different embodiment of the valve 9;

- Figure 4 schematically illustrates yet another embodiment of the valve 9 in cross section through a plane normal to the axis of the injection chamber 12;
- Figure 5 shows a cross section through the V-V plane traced in Fig. 4.

With reference to the accompanying drawings, the numeral 1 indicates as a whole a device for the thixotropic casting of products in aluminium, magnesium or other metal alloy. In the embodiments illustrated, the part to be made is a wheel rim.

The device 1 comprises an upright container 2 for a molten metal alloy (for example, an ordinary crucible) having at least one inlet 3 and one outlet 4 for the metal alloy located, respectively, at the top and bottom of the container 2.

A defined quantity of metal alloy at a temperature equal to, or just above, the liquidus is fed into the container 2 through the inlet 3. Preferably, the quantity of molten alloy fed in is measured by an appropriate metering device of known type and not illustrated in the drawings. The means for heating the alloy until it reaches the liquid state so that it can be fed into the container 2 are also of known type and not illustrated.

The device 1 also includes means 5, of known type and hence only schematically illustrated, to agitate the metal alloy in the container 2. The said means are preferably magnetodynamic devices capable of generating an electromagnetic field whose flux acts on the alloy in the container 2 to induce magnetodynamic forces strong enough to move and hence agitate the alloy in at least two directions

of rotational motion transverse to each other; the two directions of rotational motion are preferably vertical and horizontal, as indicated by the arrows 6.

Means 7 are envisaged to cool the metal alloy in the container 2, the said means preferably consisting of a coil 8 around the container 2 with a cooling liquid flowing through it.

A valve 9 shuts off the outlet 4 on command. In the embodiment illustrated in Fig. 1, the valve 9 includes a shutter 10 solidly connected to a sealed vertical stem 11 which moves relative to the container 2.

Below the container 2, there is a horizontal injection chamber 12 connected to the container 2 through the outlet 4 and connected at one end to a mould 13 of the part to be formed; at the opposite end, there is a plunger 14 that slides axially in a horizontal direction inside the injection chamber 12. The plunger 14 is used to force the metal alloy from the injection chamber 12 into the mould 13. The moulding device or press including the injection chamber 12 and the plunger 14 may, for example, be similar to that used for the injection of semi-solid billets in the known thixo-casting process

Means 15 are also envisaged to transfer the metal alloy from the container 2 to the injection chamber 12. In the embodiment being described, these means include a channel 16 having one end 17 leading into the top part of the container 2, and the opposite end connected to a source of fluid under pressure, preferably an inert gas. This source is of known type and is not illustrated. On command, the inert gas (for example, argon) can be fed into the container 2 under pressure in order to generate an overpressure which, combined

with the weight of the alloy, forces the latter out of the container through the outlet 4.

The device 1 also includes ultrasonic means 18 of known type to agitate the metal alloy in the container 2, in the proximity of the outlet 4. These ultrasonic means are arranged in such way as to operate in the lower part, usually narrower, of the container 2.

The functioning of the device 1 is described below.

First, with the valve 9 closed, a quantity of metal alloy in the liquid state, previously melted and measured by known means, is fed into the container 2 through the inlet 3 at the top of the container itself. Inside the container 2, an inert atmosphere is constantly maintained.

The cooling fluid is then circulated in the coil 8 in order to cool the alloy and, at the same time, the magnetodynamic means 5 are activated to agitate the alloy until it reaches a thixotropic state. As mentioned above, the metal is agitated by rotational motion in two directions normal to each other simultaneously.

Known means are envisaged to measure and control the temperature so that the metal undergoes a heat cycle which permits the formation of a thixotropic structure.

Ultrasonic means 8 are also envisaged to further agitate the metal.

Next, the metal alloy in the thixotropic state is fed into the injection chamber 12. During this stage, the valve 9 is opened and an overpressure is generated inside the container 2 by feeding an inert gas under pressure into the top part of the container 2. The thixotropic alloy is forced into the injection chamber by the combined action of its own weight and the overpressure in the container 2. At this

stage, the plunger 14 is in the retracted position, that is, as far to the right as possible, with reference to Fig.1.

Once the metal alloy has been transferred to the injection chamber 12, the plunger 14 is moved towards the left in such a manner as to inject the metal alloy into the cavity 27 of the mould 13. The subsequent stages in the process to obtain the moulded product are known.

The device illustrated in Fig. 2 is equipped with means 19 to inject special additives into the metal alloy so as to obtain a composite material. These injection means are of known type and include at least one ionization chamber 20, a first and second feed duct 21 and 22, respectively. The ionization chamber 20 is mounted at the top of the container 2. The first duct 21 feeds an inert gas to the ionization chamber 20. The second duct 22 feeds the said additives in solid particle form from a hopper 23 to the ionization chamber 20.

Fig. 3 shows a cutoff valve 9 designed to close the outlet 4, a slide 24 moving backwards and forwards in the horizontal direction to open and close the outlet 4.

Figs. 4 and 5 illustrate another embodiment of the valve 9 including a vertical rotating disc 25 having a number of holes 26 equidistant from the centre of the disc 25. The disc is made in such a way that, as it rotates, the outlet 4 of the container is opened when it corresponds with one of the holes 26, allowing the alloy to flow through into the injection chamber 12, and closed when it corresponds with one of the full areas of the disc 25 between the holes 26. The valve 9 shown in Figs. 4 and 5 is easy to clean.

In the heat cycle envisaged by the method disclosed, the thixotropic structure is obtained during the cooling of

the molten metal, which greatly simplifies the control of the heat cycle itself and permits a high-quality thixotropic structure to be obtained easily.

The temperature of the thixotropic metal in the injection chamber 12 is relatively high, even several Celsius degrees higher than the solidus, without giving rise to any of the problems usually encountered in the known processes such as, for example, high material wastage rate, oxidation, and formation of non-globular dendrites; in fact, the high temperature constitutes an advantage in that it allows parts with complex shapes, such as wheel rims, to be obtained.

The parts made according to the present invention have a homogeneous structure, that is, their globules are distributed uniformly in the mass of the metal.

Moreover, the effect of agitating the alloy in two directions of rotational motion 6 transverse to each other, combined with the action of the ultrasonic means 18, greatly facilitates the transfer of the metal from the container 2 to the injection chamber 12 without having to subject the argon to very high pressure.

Even in the case of complex shapes, the cavity 27 of the mould 13 is well filled since the plunger can operate effectively even at a relatively low speed, allowing the metal to flow into the mould quietly and without undue turbulence.

All the details of the invention described can be subject to modifications and variations for purposes of practical application without thereby departing from the scope of the inventive concept as claimed hereunder.

## Claims

1) A method for the thixotropic casting of metal alloy products, characterized in that it comprises the following stages:

- pouring a quantity of molten metal alloy into a container (2);
- cooling and, at the same time, agitating the metal alloy until it reaches a thixotropic state;
- feeding the metal alloy in the thixotropic state into an injection chamber (12);
- injecting the metal alloy into a cavity (27) of a mould (13).

2) The method according to claim 1, characterized in that magnetodynamic means (5) are used to agitate the metal alloy in the said container (2).

3) The method according to claim 2 characterized in that the said magnetodynamic means agitate the alloy in at least two directions of rotational motion transverse to each other.

4) The method according to claim 2 or 3 characterized in that ultrasonic means (18) are used to agitate the metal alloy in the container (2), in a zone near an outlet (4).

5) The method according to any of the foregoing claims characterized in that the stage of feeding the thixotropic metal alloy into the injection chamber (12) envisages the following steps:

- generating an overpressure inside the container (2);

- opening a valve (9) which connects the said container (2) to the said injection chamber (12).

6) The method according to any of the foregoing claims characterized in that the stage of injecting the metal alloy into the cavity of the mould (13) envisages the use of a plunger (14) that slides axially inside the injection chamber (12) and acts on the metal alloy.

7) The method according to any of the foregoing claims characterized in that the quantity of molten alloy fed into the container (2) is predetermined by an appropriate metering device.

8) The method according to any of the foregoing claims characterized in that an inert atmosphere is maintained inside the container (2).

9) The method according to any of the foregoing claims characterized in that additives are injected into the metal alloy in the container (2) through an ionization chamber (20) so as to obtain a composite material.

10) A device for the thixotropic casting of metal alloy products characterized in that it comprises:

- a container (2) for a metal alloy in the liquid state equipped with at least one inlet (3) and one outlet (4) for the metal alloy;
- means (5) for agitating and means (7) for cooling the metal alloy in the said container (2) in order to give the metal a thixotropic structure;

- a cutoff valve (9) on the said outlet;
- an injection chamber (12) connected to the said container (2) through the outlet (4);
- means (15) for transferring the metal alloy from the container (2) to the injection chamber (12);
- a mould (13) for metal alloy products connected to the injection chamber (12);
- means (14) for injecting the metal alloy from the injection chamber (12) into the mould (13).

11) The device according to claim 10 characterized in that the said means (15) for transferring the metal alloy from the container (2) to the injection chamber (12) include a channel (16) having one end leading into the top part of the container (2) and the other end connected to a source of fluid under pressure.

12) The device according to claim 11 characterized in that the said fluid is an inert gas.

13) The device according to one of the claims from 10 to 12 characterized in that the said injection means comprise a plunger (14) that slides axially inside the injection chamber (12).

14) The device according to claim 13 characterized in that the said plunger (14) runs in a horizontal direction.

15) The device according to one of the claims from 10 to 14 characterized in that the said container (2) is mounted above the injection chamber (12), the inlet (3) and the outlet (4)

being located, respectively, at the top and bottom of the container (2).

16) The device according to one of the claims from 10 to 15 characterized in that it comprises means (19) for injecting additives into the metal alloy in the container (2) so as to obtain a composite material.

17) The device according to one of the claims from 10 to 16 characterized in that it comprises ultrasonic means (18) designed to agitate the metal alloy in the container (2) in the proximity of the outlet (4).

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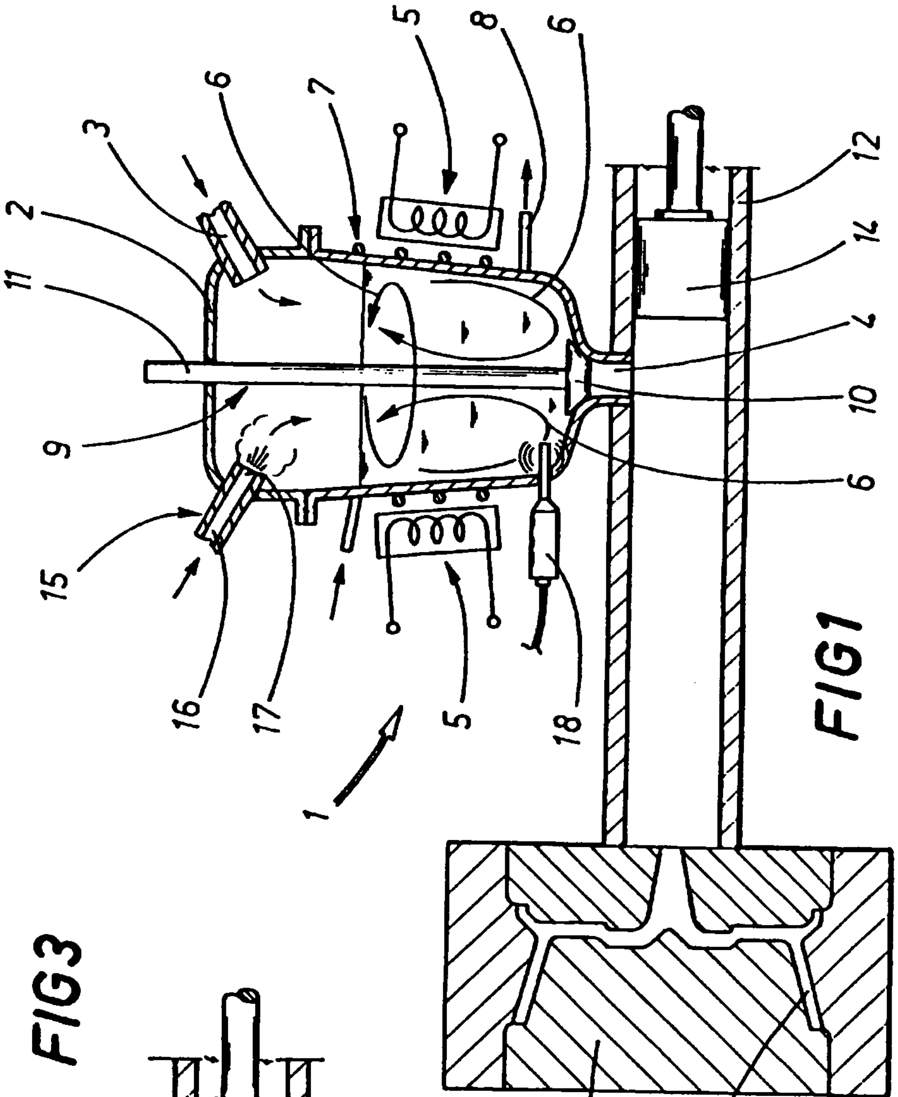

FIG1

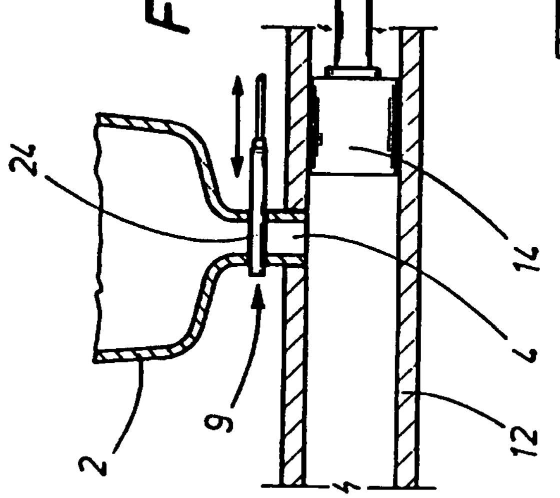

FIG3

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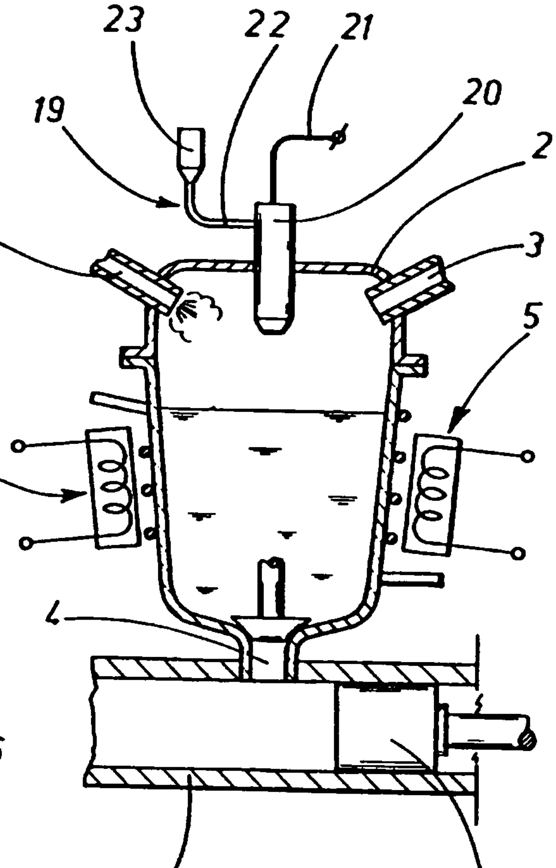



FIG2

FIG5

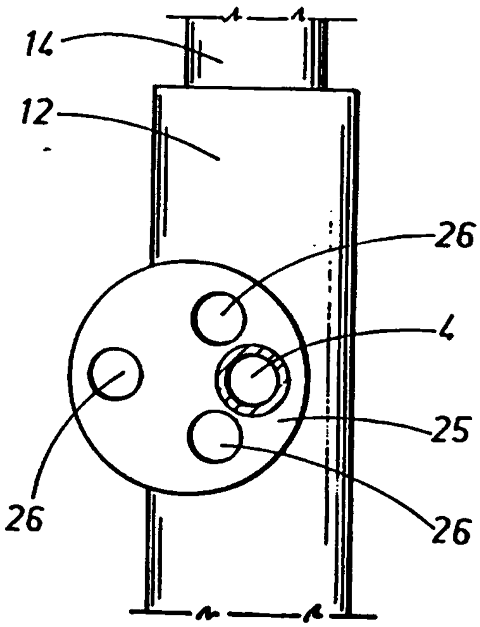
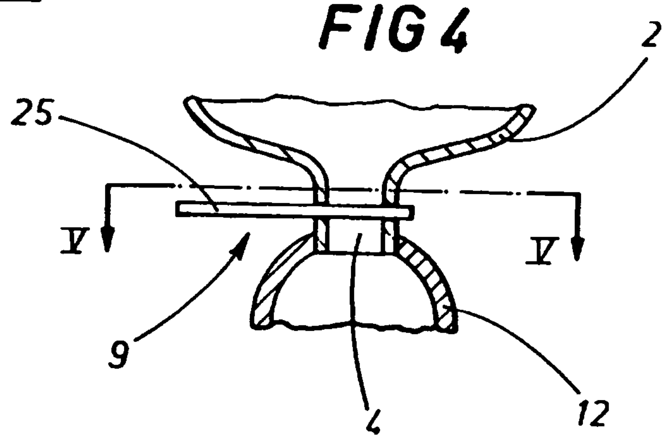



FIG 4



# INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 96/00183

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 B22D17/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B22D C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | PATENT ABSTRACTS OF JAPAN vol. 013, no. 434 (M-875), 28 September 1989 & JP 01 166874 A (AKIO NAKANO), 30 June 1989, | 1,6,9 |
| Y | see abstract | 2,10, 13-16 |
| Y | EP 0 657 235 A (RHEO TECHNOLOGY LTD) 14 June 1995 see page 9, line 32 - line 49; figures 1,7-9 | 2,10, 13-16 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat Application No
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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| | | JP-A- 7214245 | 15-08-95 |
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| | | US-A- 5555926 | 17-09-96 |